The Expulsion of the Neanderthals from Human Ancestry: Marcellin Boule and the Social Context of Scientific Research
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● *ABSTRACT*

Marcellin Boule's Neanderthal research, and his conclusion that the slouching cave brute could not be ancestral to modern man, were pillars of human paleontological theory for the first half of this century. Moving from the initial selection of the Neanderthal problem to the international acceptance of his ideas, Boule's research is analyzed in terms of various social and theoretical commitments linked to his position in the French and international paleontological communities. In particular, the paper tries to delineate the factors that made the stooping Neanderthal caricature so appealing and plausible to Boule and his contemporaries, thereby setting the stage for the infamous Piltdown forgery.

The Expulsion of the Neanderthals from Human Ancestry: Marcellin Boule and the Social Context of Scientific Research

Michael Hammond

Marcellin Boule's reconstruction of the Neanderthal skeleton found in 1908 near the French village of La Chapelle-aux-Saints was one of the most important pieces of research in twentieth-century paleontology. The 'Old Man' of La Chapelle-aux-Saints was the most complete Neanderthal skeleton known at the time, and it gave Boule a singular opportunity to solve a problem that had gripped evolutionary paleontology since the first discovery of Neanderthal fragments in 1856. Were the Neanderthals ancestral to man, or did they represent a side branch destined to disappear

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without being transformed through evolution into modern man? Boule's reconstruction of the La Chapelle-aux-Saints remains and his comprehensive comparative study of Neanderthal morphology faced this question directly. Boule expelled the Neanderthals from human ancestry.

The highlight of Boule's research was his demonstration that the Neanderthals were bipedal, but had only a slouching, incompletely erect posture. In relation to modern man, the immense morphological gulf represented by such a partially erect carriage was simply too great for evolutionary modification in the relatively small temporal gap thought to exist between the two populations. According to Boule, there were not only sufficient morphological specializations to classify the Neanderthals as a separate species in the genus *Homo*, but also the enormity of these differences, exemplified by the remarkable Neanderthal posture, meant that *Homo neanderthalensis* was a dead-end branch in the family of man. Since *Homo erectus*, discovered in Java in 1891, seemed to exhibit the Neanderthal specializations in an even more primitive form, the Neanderthal expulsion also cast doubt upon the possible ancestral status of this population. Hominid evolution must therefore have had other lines of development, and mankind's true ancestors still lay hidden in the shadows of prehistory.

Boule backed up his conclusions by producing the most detailed analysis of the Neanderthal skeleton made until that time. The enormous weight of his scholarship seemed to be matched by the fruitfulness of his evolutionary model, evident in such events as the dramatic appearance in 1912 of the Piltdown Man, whose non-Neanderthal morphology clearly pointed to these other paths of evolutionary change. Boule's theory of Neanderthal extinction without posterity became a central tenet of human paleontology for decades.

However, later re-analyses of the La Chapelle-aux-Saints skeleton and the comparative study of other Neanderthal remains raised many questions about this famous reconstruction. One suggestion was that the skeleton's relatively straight spinal column, which lacked the curvature necessary for fully erect posture, was the product of pathological deformation by osteoarthritis and was not a genetically transmitted aspect of Neanderthal morphology.[1] Boule had noted the osteoarthritis on many of the vertebrae, but he never seemed to have considered that the postural stance of this skeleton might have been related to the disease. Another criticism

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concerned the range of variation in modern man of morphological characteristics, especially in the spinal column and the bones of the lower limbs and feet, supposedly associated with this unusual posture. Although the Neanderthal norms of these characteristics might have varied from those of a Parisian population at the turn of the century, it seemed that Boule had not given full consideration to studies by his contemporaries that discussed the wide variation of these characteristics in existent populations, especially outside Europe.[2] Thirdly, it appeared that Boule had failed to emphasize or had ignored certain other characteristics that pointed to a fully erect posture.[3] Fourthly, it seemed that Boule had given too much emphasis to some morphological characteristics that later studies showed did not necessarily entail an imperfectly erect posture.[4]

A common theme united these controversial areas of Boule's analysis of Neanderthal posture. Each involved a decision by Boule that increased the morphological distance between the Neanderthals and modern man, and therefore decreased the likelihood that the Neanderthals were ancestral to man. The question then becomes, what was there that might have predisposed Boule to consistently interpret the Old Man of La Chapelle-aux-Saints, as well as the other Neanderthal skeletons in his laboratory, in terms which made the stooping posture so overwhelmingly plausible? This paper focuses upon Boule's scientific context in order to try to reconstruct the overriding image and perspective that led Boule to eliminate the Neanderthals as possible forefathers to man. Boule's research is analyzed in relation to his location at the Laboratory of Paleontology in the Museum of Natural History in Paris, and to his position in the French paleontological community.

After reviewing the history of the Neanderthal problem in paleontology and the progress of the La Chapelle-aux-Saints reconstruction, this paper will discuss nine factors which may have played a part in Boule's depiction of the Neanderthal fate:

1. Discipleship and problem choice.
2. Good fortune in initiating a research project.
3. Prior success and the emergence of an investigative strategy.
4. A commitment at a research institution to theory as synthesization.
5. The avoidance of aetiology in a research laboratory.
6. Competing research programmes.
7. Fortuitous fraudulence.

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8. International rivalries.
9. New institutionalization and improved strategic position.

This paper assumes that, like any other human activity, scientific research is to some extent inseparable from the historical context in which the activity occurs. It does not attempt to develop or to test any general theory tying scientific research to social structure, but it is based upon the belief that there is no a priori reason to exclude any aspect of Boule's work from historical analysis. In the tradition of Barry Barnes, Steven Shapin and others, the approach used here is a naturalistic one.[5] This study treats science as any other cultural product, to be analyzed case by case. It does not seek to debunk Boule in particular or paleontological science in general, just as it does not place science on a pedestal looming over other types of knowledge. Since the emphasis is upon research traditions, patterns of training, and micropolitics, this study could be classified as largely 'internalist' in that the primary focus is upon the scientific subculture of French paleontology. However, from the naturalistic perspective, such a label does not imply that the scientific research being analyzed is therefore more or less rational or irrational than science that might best be analyzed from a macro-political externalist approach, or from an approach which emphasizes internalist cognitive developments. Similarly, this paper does not make an assessment about what should, or should not, be the 'correct' position to take in regard to Neanderthal ancestral status.[6]

The Neanderthal Problem in 1908

The discovery in 1856 of a primitive skull at Neanderthal in Germany touched off a long controversy.[7] For many scientists defending an anti-evolutionary position, Neanderthal Man was simply a modern man pathologically deformed by rickets and arthritis. For others, this population was an unsuccessful evolutionary experiment that disappeared in the shadows of prehistory. For yet others, the Neanderthals were ancestral to man, or at least were tied to 'inferior races' such as the Australian aborigines. Throughout the rest of the century, there were many discoveries of Neanderthal fragments in Europe; and as evolutionary paleontology came to be accepted, so too was the ancestral status of the Neanderthals increasingly believed in. Although these discoveries were of extremely incomplete skeletons, the sum total of fossil fragments was

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significant. With his bestial brow ridge, retreating forehead, and massive jaw, the Neanderthal seemed to represent an ideal missing link between modern man and some earlier stage of evolutionary development. The discovery in Java in the early 1890s of *Pithecanthropus erectus* (now generally labelled *Homo erectus*) seemed to indicate this earlier stage, and many scientists came to see human evolution as a broad linear series 'passing step by step from a Simian to a modern type of man'.[8] French advocacy of such an evolutionary ladder was led by Gabriel de Mortillet, who placed the Neanderthals at the intermediate stage between man and the Homosimians, represented by Eugene Dubois' discovery in Java.[9]

However, around the turn of the century, certain anomalies appeared. In 1899, a major discovery at Krapina (in present day Yugoslavia) seemed to indicate the simultaneous or nearly simultaneous presence of two populations, one Neanderthal and another more modern in morphology. In 1901, excavations at the Grimaldi Caves on the Mediterranean coast of France also seemed to show that the Neanderthals and the morphologically more progressive Grimaldi Man had existed quite close together in time. Marcellin Boule was one of the scientists working at this site, which was excavated upon the patronage of Albert I, the Prince of Monaco.

Boule placed Grimaldi almost coexistent in time with the Mousterian cultural period of the Neanderthals,[10] but his teacher and friend, Émile Cartailhac, thought that Grimaldi Man belonged to the following cultural period, the Aurignacian.[11] In both cases however, there appeared to be at best only a relatively small temporal gap between the Neanderthals and the essentially modern Grimaldi Man. This made it crucial to determine just how different the Neanderthals were morphologically, and hence to determine just how much of a temporal gulf was necessary to make an evolutionary relationship possible, or just how close a dating between the two populations would remove the Neanderthals from direct human ancestry. What was lacking was a well dated and relatively complete single skeleton that could settle the questions about the exact nature of Neanderthal morphology.

It was just such a skeleton that was unearthed in August 1908 by three clerical prehistorians, the Abbés J. and F. Bouyssonie and L. Bardon. The skeleton was sent to Boule and arrived at the Museum of Natural History in early November 1908. La Chapelle-aux-Saints was the most complete Neanderthal skeleton discovered until that

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time. It still possessed twenty vertebrae — parts largely lacking in previous discoveries and a key to the reconstruction of the spinal column, which is a critical indicator of bodily posture. In the Fall of 1909, a newly discovered Neanderthal skeleton from La Ferrassie arrived in Boule's laboratory, followed by La Ferrassie II in 1910. Although Boule considered neither as important as La Chapelle-aux-Saints,[12] they provided new comparative material to add to his skeleton and his casts of many previously discovered Neanderthals: and both were useful in filling in areas where the La Chapelle-aux-Saints remains were weak, such as the tibias and femurs.[13] Clearly, for Boule, La Chapelle-aux-Saints was to be the 'type' specimen for the Neanderthals, and the presence of these new Neanderthal skeletons produced no changes in the conclusions he originally based upon the La Chapelle-aux-Saints reconstruction.

Boule's Reconstruction and its Later Re-Analysis

The reconstruction was essentially a one-man effort. All the publications were in Boule's name alone, except for the work on the interior brain case, where one of his lab assistants, Raoul Anthony, was listed as second author.[14] Boule generously recognized the role of his other assistants in different parts of the reconstruction and publication presentations, but all of these other contributions were technical and secondary.[15] La Chapelle-aux-Saints was Boule's *chef d'oeuvre* and its study was completely under his control.

Boule presented his initial conclusions in reports to the Academy of Sciences on 14 December 1908, 17 May 1909, and 7 June 1909.[16] His basic conclusions were that:

1. The mid-Pleistocene dating of the geological and faunal associations with the burial completely eliminated the possibility that the Neanderthals were simply freakish human skeletons of recent origin.
2. With its retreating forehead, prominent orbital arches, large but flattened brain case, massive jaw, and nearly absent chin, this Neanderthal exhibited the outstanding cranial characteristics of other previously discovered Neanderthals, thereby indicating that this population was essentially homogeneous morphologically and was apparently closer to simian ancestry that any other member of the genus.
3. Simian-like characteristics also marked many other parts of the skeleton, with its elongated, non-retroverted, and non-bifurcated cervical spinal processes; its short and massive vertebral column lacking curvature in the cervical and lum-

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bar regions; its femoral shaft bowing and tibial plateau retroversion; and its foot structure which placed the body weight on the outside edge and had a divergent great toe. All of these specializations pointed to an incompletely erect posture unlike that of any modern population of man.

4. Although such morphological characteristics put the Neanderthals in an intermediate position between the Pithecanthropines of Java and certain contemporary races of modern man, this did not mean that the Neanderthals played a part in the origin of man. Since an essentially morphologically modern population such as Grimaldi Man existed at a time not far removed from that of the La Chapelle-aux-Saints skeleton, the Neanderthals, marked as they were by so many morphological differences, must be removed from human origins. These origins must be found further back in prehistory than had been generally thought.

Boule then undertook a study of the interior of the brain case in order to try to determine the degree of cerebral development. Although the brain case was quite large, the mould taken of the interior indicated less well developed cerebral lobes and other primitive aspects in comparison to the modern human brain.[17] Therefore, even though it was quantitatively equal or even superior to a modern brain, it was qualitatively inferior.

These many conclusions were expanded and presented in Boule's magisterial publications in the *Annales de Paléontologie*, which appeared between October 1911 and March 1913.[18] In this most complete study ever done of the Neanderthals before World War I, each part was carefully described, and compared to apes, other Neanderthals and modern man. The Neanderthal fate was now definitive. There was an enormous morphological gap and only a small temporal gulf between the Neanderthals and man. Thus, the Neanderthals were 'doubly fossil', in the sense that they were a genuine fossil population, and that they became extinct without ancestry to modern man.[19]

So powerful was the effect of Boule's research on the European Neanderthals that the La Chapelle-aux-Saints skeleton was not re-examined in detail until the mid-1950s. We shall see below some of the reasons for this forty year gap. In their re-analysis, W.L. Straus and A.J.E. Cave stressed that the skeleton was afflicted by osteoarthritis, evident on three of the five cervical vertebrae, three of the eleven thoracic vertebrae, all four lumbar vertebrae, and on one hip fragment.[20] The 'Old Man' had suffered for many years from this pathological condition. A common postural consequence of this disease is a straightening of the spine, and in all likelihood, this Neanderthal did not walk fully upright in the last years of his life.[21]

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Boule had estimated the age of the skeleton at between fifty and fifty-five years, and he had mentioned the osteoarthritis in passing.[22] However, he never seemed to consider these as possibly important variables in reconstructing Neanderthal posture. In terms of N.R. Hanson's classic distinction between 'seeing' and 'seeing that',[23] Boule clearly saw the evidence for the pathological condition, but he did not see that this provided the basis for a possible alternative explanation for the remarkable posture of the skeleton.

Boule's non-emphasis on pathological deformation was, of course, only one in a series of important decisions he made in regard to the spinal column. For instance, his depiction of the straight cervical spine was also based upon his belief that the 'distinctly simian arrangement of the spinous processes', evident in their length and non-retroversion, clearly indicated a simian-like development of the cervical vertebrae, which in turn pointed to a simian-like lack of curvature.[24] These primitive characteristics of the vertebrae were paralleled by their general non-bifidity, which was not in itself outside the range of variation of modern populations, but which, combined with these other characteristics, also indicated a less than fully human development.[25] Thus, although none of these characteristics are accepted today as so positively indicating a stooping and pre-modern human posture, Boule could still have argued that even taking into account the osteoarthritic deformation, the La Chapelle-aux-Saints vertebrae were still sufficiently different to suggest an incompletely erect carriage.

These problems about the spinal column are important because this part of Neanderthal morphology was central to other research decisions Boule made, and to his final conclusion as to the Neanderthal evolutionary fate. For instance, Boule recognized that many other characteristics of Neanderthal morphology, such as the femoral shaft bowing, the tibial plateau retroversion, or the ankle and foot structure which put weight on its outer edge and had an almost prehensile great toe, were not outside the range of variation of modern man, and hence did not constitute in themselves grounds for giving the Neanderthals a slouching posture.[26] However, Boule argued that never had such characteristics been associated with the general lack of curvature in the spinal column.[27] Since this curvature is crucial to fully erect posture, Boule believed that these other specializations were not the result of special environmental

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conditions, as sometimes occurs in modern populations, but were instead a part of the genetically transmitted series of traits producing the hunchback position exemplified by the La Chapelle-aux-Saints skeleton.[28] This postural depiction was in turn central to postulating the evolutionary extinction of the Neanderthals. Boule's analysis of other Neanderthal characteristics, such as the large jaw, brow ridges, and cranial specializations, might have been sufficient to create a non-*Homo sapiens* categorization for the Neanderthals: but at the end of the first decade of this century, without the stooping carriage, the morphological differences between the Neanderthals and modern man would not have been sufficient to so definitively expel the Neanderthals from a place in the evolutionary origin of man.

If Boule had chosen a different pattern of analytical focusing, the fate of the Neanderthals might have been different. For instance, if he had highlighted the osteoarthritis and stressed the range of variation of many morphological characteristics in modern man, then it would have been possible to conclude that although the La Chapelle-aux-Saints 'Old Man' did not walk fully upright late in his life, there was no reason to assume that a younger and healthier Neanderthal had a posture significantly different from modern man. In such a case, the total morphological distance between these two populations would not be too great. Since the temporal gulf indicated by faunal and cultural dating was also not too large according to the data available in 1908, the Neanderthals could still appear as a possible candidate for the forefathers of modern man.

This was not of course how Boule perceived the evidence or drew his conclusions. In relation to Boule's presentation of the Neanderthals, I have been able to find absolutely no indication, or even a hint, that Boule fudged or fraudulently mis-reported his research. Boule sincerely looked upon science as 'one of the principal sources of happiness' when 'guided by that interior flame', the 'love of Truth'.[29] His La Chapelle-aux-Saints reconstruction was his most important contribution to this search; and he believed that the best scientific techniques available had been used, and that his conclusions were dictated only by the data themselves.[30] Thus, in this reconstruction of Boule's scientific research, we must turn to Boule's own social-historical context in order to try to develop the pattern of selective focus that made the slouching Neanderthal

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posture and the tragic Neanderthal fate so overwhelmingly plausible for Boule and his contemporaries.

Boule's Context: Nine Factors

Discipleship and Problem Choice

We might first ask, why did Boule devote himself in the early years of this century to a study of the possible fossil ancestors to man? In 1902, he became professor of paleontology at the Museum of Natural History, succeeding his teacher, patron, and friend, Albert Gaudry. As a true disciple, Boule described his role in the Laboratory of Paleontology as 'widening the path' already traced for him by Gaudry.[31] Such a commitment entailed a venture into the 'agonizing problem of human origins', an area of paleontology that Gaudry had carefully avoided while at the Museum.[32]

Boule first met Gaudry when he came from Toulouse to Paris in 1886 to pursue his doctoral degree. Although originally a student of geology, he was attracted to the personality and character of Gaudry, and to the study of paleontology, which appeared to have more important philosophical implications than his original field.[33] In 1890, he joined Gaudry's laboratory, becoming a demonstrator in 1892, assistant professor in 1894, interim professor in 1900-01 while Gaudry was on leave; and in 1902, with Gaudry's blessing and support, he became full professor when Gaudry retired. Boule's admiration for Gaudry knew few bounds, as year after year they worked together in the Laboratory of Paleontology 'without the smallest cloud ever troubling the serenity of our life'.[34] One friend described their relationship by noting that a 'curious and touching intimacy definitively joined these two men in a deep esteem and friendship'.[35]

Gaudry traced the evolutionary path of hundreds of species, demonstrating that evolutionary change usually showed a complex and irregular branching pattern marked by numerous extinct dead ends as well as sudden evolutionary transformations. Although recognized internationally as an expert on fossil primates, making him a likely scientist to try to assess the evolutionary status of the Neanderthals and *Homo erectus*, he had carefully avoided the question of human evolution. The source of Gaudry's silence is found in the social history of French paleon-

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tology.[36] The resistance to the new science of evolution after 1860 was particularly strong in France, in part because many of the key positions in the highly centralized scientific structure surrounding the Museum and the Academy of Sciences were occupied by individuals such as Élie de Beaumont and Pierre Flourens, who were disciples of the anti-evolutionary tradition of Georges Cuvier.[37] In his heroic efforts to promote the science of evolution in the face of the powerful and institutionally entrenched anti-evolutionists in official French science, Gaudry practised decades of delicate scientific diplomacy.[38] This involved in part a general silence on the especially delicate problems of human evolution; and only in the very last years of his life, after his retirement from the Museum, did Gaudry begin to touch upon certain details of the descent of man.[39]

When Boule succeeded Gaudry in 1902, much of the traditional opposition to evolution had faded, and there were no longer any significant institutional imperatives to avoid the supreme question. By this time, Boule had already touched upon many aspects of human paleontology, especially in regard to the use of geology and non-human paleontology in dating fossil remains; but as yet there had been no reconstruction of fossils from the family of man in the Laboratory of Paleontology.

Given Boule's devotion to Gaudry and his own interest in the problem of human evolution, it was virtually inevitable that he would take up this question in the first years of the century, and try to fill the last link remaining in the evolutionary catalogue begun by his teacher. In his commitment to 'widening the path' of Gaudry's tradition, Boule could scarcely avoid the Neanderthals, who were the major fossil population discovered in Europe at this time. His two years of work on the Grimaldi site had represented a beginning in this regard, but it was only in 1908 with the La Chapelle-aux-Saints skeleton that Boule came upon the supreme opportunity to probe in depth the Neanderthal issue.

Almost prophetically, Boule received the skeleton just two weeks before Gaudry's death, after a long and painful illness, on 27 November. His first presentation to the Academy of Sciences on 14 December marked the beginning of his endeavours to prove that the path opened by Gaudry led not only to an understanding of the pattern of non-human evolution, but also to a comprehension of the course of human evolution.

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Good Fortune in Initiating a Research Project

Despite his commitment to making the Laboratory of Paleontology a centre for the study of human evolution after the retirement of Gaudry, it was by no means inevitable that a discovery in France such as La Chapelle-aux-Saints would come to Boule. He himself did not unearth the skeleton. Its discoverers were the clerical prehistorians, the Abbés F. and J. Bouyssonie and L. Bardon, who were not skilled anatomists and could not undertake the difficult reconstruction themselves. Upon the advice of another clerical prehistorian, the Abbé Henri Breuil, they sent the skeleton to Boule.[40] Of course, in holding the chair of paleontology at the Museum, Boule occupied one of the most central positions for the study of evolution in France. He had also shown a keen interest in the Neanderthal problem during the Grimaldi excavation, but these factors by no means meant that any Neanderthal discovery in France would end up in his laboratory.

Quite the opposite was the case. For instance, in 1908, the Swiss-German prehistorian and personal enemy of Boule, Otto Hauser, had sent the Neanderthal discovery at Le Moustier to Germany. Had La Chapelle-aux-Saints been unearthed by one of the French archaeologists in the tradition of Gabriel de Mortillet of the École d'Anthropologie in Paris, such as Paul Girod, the skeleton would probably have been sent to Leon Manouvrier at the École, which was (as we shall see later) the traditional rival to the Museum in this scientific field. However, the anti-clerical traditions of the École meant that it was unlikely that the Abbés Bouyssonie and Bardon would send their discovery there. Also, Breuil had a long association with Boule that went back to the influence of their mutual teacher, Émile Cartailhac, in Toulouse. Thus, for a variety of reasons tied to the social divisions in the community, the skeleton ended up in Boule's laboratory.

In the science of paleontology, a firm conjecture and access to adequate research facilities are only two parts of the process necessary to prove or disprove a hypothesis. There is also the necessity that the appropriate fossil material be available and datable; but there is no guarantee that any particular excavation will yield a specific skeletal type, or that even the right type of skeleton will be sufficiently complete to reach any definite conclusions. Hence, Boule was doubly lucky in that it was these three clerics who found the La Chapelle-aux-Saints skeleton, and that the

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skeleton itself was complete enough to permit concentration on the theretofore unresolved question of Neanderthal posture. However, good fortune was not the only factor helping to initiate this research project. If Pasteur's contention that 'chance favours only the prepared mind' is correct, then there could hardly have been a scientist more prepared than Boule to deal with the Neanderthals, given his long experience in paleontological reconstruction, his control of the resources in the Laboratory of Paleontology, and his interest in the Neanderthal problem.

Prior Success and the Emergence of an Investigative Strategy

One of the key social processes in science is the formulation of a set of norms about procedural rules, standards, intellectual conventions, and tactics.[41] In Boule's case, such a normative strategy evolved during decades of internationally recognized research on non-human fossils. Using the same approach that had produced success after success in his early career, Boule explicitly tried to treat the La Chapelle-aux-Saints remains just like any other fossil he had studied.[42] This commitment entailed a detailed description of every aspect of the skeleton, a dating of the skeleton through geological or paleontological referents, a comparison of the fossil to other members of the same species if available, and also to other zoologically related species, and finally, an assessment of the possible evolutionary linkages between the fossil and other members of the same family. The most important decisions in this last step were to assess whether the relationship between fossil species was linear or branching ancestry, or unrelated parallel but separate development; and, if the tie was branching, to decide whether the species evolved further or whether its branch represented an evolutionary blind alley.

By 1908, Boule had built a substantial career with this approach. For instance, in his study of the fossil reptile, *Callibrachion Gaudryi*, which had the extraordinary morphological combination of a primitive brain and spinal column along with a quite modern limb morphology, he demonstrated that such a combination was not anomalous if seen as representing an unsuccessful dead end in evolutionary development.[43] In his study of *Canis megamastoides*, he showed the collateral and separate development of certain mor-

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phological traits in species previously thought to be linked ancestrally.[44] In his studies of fossil mammals from rabbits to rhinoceroses, often done in collaboration with Gaudry, he demonstrated time after time that many groups had independent origins far earlier in prehistory than had been thought; that species often believed to be ancestral to another species were in fact collateral dead ends; and that the true ancestors of the successful branch must be sought earlier in time.[45]

Much the same pattern was evident in Boule's pre-1908 work on human prehistory. His study of European glacial geology and faunal associations at human archeological sites showed that these developments were more intricate and variable than had been believed by previous prehistorians.[46] For instance, at Grimaldi, he noted a Mousterian cultural level contemporary with Chellean fauna, which in terms of the classic version of archaeological succession from the Chellean to the Mousterian, would have been impossible.[47]

La Chapelle-aux-Saints capped these studies by demonstrating that in the family of man, species like the Neanderthals, which were previously thought to be ancestral, were in fact collateral. They represented extinct dead ends, and pointed to the conclusion that although temporarily lost in the shadows of prehistory, man's true ancestors existed far earlier than had been previously thought.[48] Thus, Boule once again showed that unusual morphological specializations, such as those of the Neanderthals, could be satisfactorily accounted for by rejecting the model of linear development and using instead a branching model of irregular extinction and transformation.

In this regard, C. Loring Brace and Stephen Holtzman have raised the question of whether prior belief shaped Boule's perception of La Chapelle-aux-Saints and the nature of his conclusions.[49] Brace has argued that Boule was a closet Cuvierian who, like Gaudry, was opposed to the very idea of human evolution, and was therefore predisposed to eliminate all candidates for human ancestry, such as the Neanderthals. Holtzman has challenged Brace's notion, and argued that Boule's vision was primarily grounded in the multilinear tradition of Gaudry. Holtzman is correct in looking to Gaudry for one intellectual source of Boule's evolutionary doctrines, but two other points should be made.

As noted above, Boule's ties to Gaudry were also emotional and social, going much deeper than a basic intellectual tie, and thereby

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decreasing the likelihood that his theoretical conclusions would break with those of his beloved teacher. Such a symmetry required, of course, the elimination of some populations in the family of man, such as the Neanderthals, from ancestry in order to reproduce Gaudry's branching vision. Victor Hugo's famous line about the death of his mistress had been invoked at Gaudry's funeral, 'Les morts sont les invisibles, mais ils ne sont pas les absents';[50] and it is indeed possible to see the ghost of Gaudry casting its spell over La Chapelle-aux-Saints.

Secondly, Boule's conclusions should also be seen in relation to his own past decades of research which had proven so acceptable in his scientific field. By proceeding just as he had many times before, he showed that by the accepted standards of the community, the Neanderthals were a separate species,[51] and that in terms of the branching convention, their fate was that of a multitude of other species.[52] Through the Neanderthal expulsion, Boule showed that the careful and exhaustive comparative techniques known to be so fruitful in studying non-human evolution were just as useful in analyzing human evolution. The same procedures had led to the same conclusions, as in any good science. In this sense, it is no wonder that Boule was clearly not surprised by the results of his La Chapelle-aux-Saints reconstruction, which so successfully reduced in his words the 'zoological isolation' between the evolutionary path of man and other species.[53]

This evolutionary uniformity also had implications within the Museum of Natural History. Boule had long opposed those in the Museum who considered paleontology to be an artificial discipline that should be subsumed under other fields such as biology, zoology, and anthropology.[54] Boule's theory of Neanderthal extinction demonstrated that such a dismembering was uncalled for, since in fact there was methodological and theoretical unity in human and non-human paleontology. Throughout the years, Boule used his Neanderthal research as the keystone in his efforts to defend his discipline's hard-won boundaries.[55]

Boule's work became a methodological exemplar for the community, and set the standards for the highest level of acceptableness in comparative paleontology. This model of branching evolution also proved very useful over the following decades in dealing with new fossil discoveries. The same conclusion appeared again and again as other fossil populations in the family of man were shown to be 'doubly fossil', just like the Neanderthals. For instance,

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Homo erectus from Java and Peking and Raymond Dart's Australopithecines from South Africa were consigned by the paleontological community to collateral extinct branches.[56]

A Commitment at a Research Institution to Theory as Synthesization

Boule saw 'illuminating syntheses' as the hallmark of good science in general and French science in particular,[57] and his deep satisfaction with the unification of paleontology through the Neanderthal expulsion was reflected in his conclusions that now, 'the science of paleontology is *one*, whether concerned with man or animals' (italics his).[58] However, this synthetic theme was never explicitly at issue during any specific part of the research process, but appeared *ex post facto* when discussing the implications and satisfactions of the research results. In Gerald Holton's terms,[59] Boule's attraction to syntheses could be seen as an example of a themata which 'constrains' and 'motivates' a scientist without ever becoming an explicit part of research. In regard to the Neanderthal problem, Boule's attachment to 'illuminating syntheses' could, through the 'strong grip' of thematic commitment, both 'motivate' him towards the creation of the morphological gulf between man and the Neanderthals necessary to unify paleontology, and 'constrain' him from seeing possible alternative explanations for the La Chapelle-aux-Saints skeletal specializations.

Such a commitment to synthesization was an integral part of scientific socialization in paleontology at the Museum of Natural History. The founder of the modern discipline in France, Georges Cuvier, had been devoted to the unification of geology and paleontology in his anti-evolutionary catastrophist model. This commitment was continued not only by his disciples such as Alcide d'Orbigny, but also by their students such as Albert Gaudry. Gaudry himself laboured to demonstrate that the evolution of an enormous variety of species showed a remarkably uniform pattern, even though he remained limited by his self-imposed silence on human evolution from trying to tie together human and non-human paleontology. Gaudry's student, Marcellin Boule, accomplished this last step, and commentators on Boule's career in the Museum constantly noted his commitment to the synthetic tradition.[60]

The importance of this synthetic themata in 1908 was that, since

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non-human paleontology had clearly shown non-linearity to be the evolutionary pattern of more and more species, synthesis was only possible through the expulsion of populations such as the Neanderthals from human ancestry. There is no way to show directly a thematic effect during the research process, since such commitments operate implicitly and only sometimes appear when research results are reported. However, it seems more than coincidental that Boule's consistent perception of primitive Neanderthal characteristics happened to be the very perceptual pattern that would create such a paleontological synthesis.

The Avoidance of Aetiology in a Research Laboratory

Boule's Neanderthal research not only set the standards for work in the paleontological community and promoted a commitment to theoretical synthesis, but it also had another important normative effect based upon its consistent silence on the problem of causality. This choice not to deal with aetiological questions raised by the Neanderthal expulsion was one of the most important and intriguing research decisions made by Boule. Except for a few lines noting that he had no solution to the problem, the question of how the Neanderthals became extinct and were replaced in Europe by modern man was never discussed.[61] This was despite the fact that the precise nature of Neanderthal extinction was one of the thorniest issues raised by Boule's work. Instead, Boule limited himself strictly to a descriptive level of analysis, and maintained a silence on causality.

Such a silence had been for decades an integral part of work in the Laboratory of Paleontology. As part of his conciliatory scientific politics, Gaudry had generally avoided public discussion of the basic causes of evolutionary change. In France, this had long been the issue which pitted spiritualist against materialist and divine creationist against Darwinian in bitter polemics. Gaudry himself was a devout Catholic, and from time to time, referred vaguely to a plan for evolutionary development somewhat related to a Divine presence; but, for the most part, his work was purely descriptive.[62]

Boule was even more circumspect, and in the thousands of pages he published on almost every aspect of paleontology, there is no general discussion of causality in non-human or human development. It is difficult to believe that a scientist who had spent his life

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studying evolutionary change would have no opinion on such matters, but like Gaudry, Boule was a conciliatory scientific diplomat.[63] He sought to enlarge the community studying evolution, while insisting that only paleontology could resolve paleontological problems.[64] This both effectively maintained his disciplinary boundaries and simultaneously stirred up a minimum of wider controversies in an area notorious for overflowing its borders and engaging in struggles over fate, chance, spiritualism, materialism, and the like. Silence about aetiology accomplished such ends very well.

In regard to a particular piece of research such as La Chapelle-aux-Saints, this institutionalized avoidance of causal questions in the Laboratory of Paleontology meant that Boule did not have to grapple with two of the most potentially difficult problems in the elimination of the Neanderthals from human ancestry. The nineteenth-century solution for those who gave ancestral status to the Neanderthals, such as Gabriel de Mortillet, was relatively easy. The Neanderthals populated Europe, there was a major environmental change with the glaciers covering much of the continent, and under these changing conditions, the Neanderthals were transformed into modern man, and their stone tool culture evolved into a more advanced culture.[65] In contrast, Boule's conclusions meant that multiple populations of the genus *Homo* had existed at much the same time in prehistory, and sometimes even occupied the same sites. To explain how, for instance, in Darwinian terms the same environmental changes might have led to such radically different fates for these different populations would be by no means easy.

Secondly, the Neanderthals had a stone tool culture, as well as some type of religious system, indicated by the fact that the 'Old Man' of La Chapelle-aux-Saints was formally buried.[66] In terms of cultural evolution, explaining how such a culture disappeared without a trace would also not be too easy. Indeed, if one of the requirements of Neanderthal research for Boule had been the production of an explanation for why the pattern he described actually occurred, he might have been more hesitant in decisively expunging the Neanderthals from human ancestry and been pressed to consider more deeply the implications of his morphological conclusions. However, in the Laboratory of Paleontology, the relationship between changes in environmental conditions, culture, and morphology was not at issue, and it was possible to concentrate

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almost exclusively upon descriptive morphology. In addition, such an avoidance of cultural issues might have been in part affected by Boule's investigative strategy founded in non-human paleontology, where he and his contemporaries also assumed that culture plays no causal role in evolutionary change.

Boule's apparently successful wager that human paleontology could proceed without causal analysis provided a tremendous boost to his discipline. His rallying cry that only paleontology could resolve paleontological problems became a hallmark of studies for decades, with the result that genetics, biology, cultural anthropology, and other potentially related fields came to play for many years only a minor role in the study of the physical evolution of man.

Competing Research Programmes

An analysis of the social process of scientific research must take into account the traditions to which that research was opposed. Boule's silence on causality, as well as his affinity with the branching model, reflected well his social location at the centre of a network of scientists challenging the dominant late nineteenth-century vision of linear, materialist evolution. For Boule, one of the most important results of his Neanderthal research was that it demonstrated that evolutionary change 'is not accomplished as simply as was believed in the beginnings of the science; that unilinear series appear to us as more and more rare; and if they exist, it is extremely difficult to find them or to pursue them for any length of time'.[67] Such a conclusion reversed the findings of the leading French advocate of the unilinear series, Gabriel de Mortillet, whose life and work Boule had long criticized.

In Imre Lakatos's terms, any research programme is based upon a hard core of postulates which serves to organize and solve a vast array of discoveries and problems.[68] Mortillet's core assumptions were that species in man's family *Hominidae*, as well as human cultures, evolve; that this evolution almost always takes place in a progressive linear path; that materialistic factors are the key causes of these progressions; and that, in social terms, the progress of evolutionary science cannot occur without progressive social change and constant battle with organized religion and its scientific accomplices.[69] While such a programme embroiled the Mortille-

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tians in a number of political and religious controversies, it also served as a comprehensive framework with which to study all aspects of prehistory.

First formulated in 1867 at a time when dating techniques were not too well developed, this programme was immensely successful in bringing order to the vast amount of data that was being brought to light in the late nineteenth century. Most importantly, such an approach made possible dating by level of comparative development. For instance, since the Neanderthals were more primitive morphologically than modern man, as shown in their brain case and jaw features, they must have existed earlier in prehistory. If they existed earlier, they must also be ancestral, according to the laws of progressive linear development. Similarly, *Homo erectus*, who was more primitive than the Neanderthals, was earlier in time and ancestral to the Neanderthals.[70]

To explain the evolution of the Neanderthals into modern man, Mortillet invoked a single great European glacial period whose severe environmental conditions became the basis for this evolutionary progression.[71] In paleoarchaeology, there was a parallel ladder from the pre-Neanderthal eoliths, to the Neanderthal Chellean culture,[72] and upwards to three other major cultural periods, each one more sophisticated and progressive in cultural development. Such classifications based on levels of comparative development were a wonderful and influential tool; but their success was short lived.

In 1888, Boule attacked the glacial geology in Mortillet's model;[73] and over the next years, he described Mortillet's theoretical system as a 'mirage of doctrines', and a 'mummy which he encircles every day with new bandages' in order to protect it from scientific criticism.[74] Mortillet died in 1898, and a few years later, Boule's friend, the Abbé Henri Breuil, began the assault on Mortillet's paleoarchaeological scheme by demonstrating that in fact human cultural evolution was not as elegantly simple and ordered as Mortillet had believed. This meant that by 1908, all that was left of Mortillet's classifications was the linear paleontological ladder, and this Boule demolished. Thus, the Neanderthal expulsion was but one step in the dismantling of the most influential evolutionary research programme in late nineteenth-century France. Naturally, the plausibility of Boule's Neanderthal analysis was increased in the face of the eclipse of the linear model in geology and paleoarchaeology.

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In addition, Boule's opposition to the linear model had a sociopolitical undercurrent. The centralized and hierarchically structured nature of French scientific communities had meant that the institutionally embedded defenders of anti-evolutionary orthodoxy were well located to resist the resurgence of evolutionary thinking after 1859. In the face of this opposition, evolutionists had to decide which was the best way to confront this scientific establishment. Gaudry chose the diplomatic path, avoiding questions of human evolution and trying quietly to introduce a non-materialist evolutionary perspective into the heart of official French science at the Museum of Natural History and the Academy of Sciences. In contrast, Mortillet chose to create a 'combat anthropology' to fight what he saw as the 'war without truce' led by the anti-evolutionists and their powerful clerical allies.[75] He attacked the 'non-entities' in the Academy,[76] ridiculed the 'clerical intransigents' who tried to fuse science and religion,[77] and published tracts such as *Le Signe de la Croix avant le Christianisme*, using archaeology to debunk Christian symbolism.[78]

Mortillet also led a double scientific and political career, sitting in the Chamber of Deputies on the extreme left, and serving as mayor for a district of Paris.[79] He and his followers used their scientific and political influence to help found, and later take over, the École d'Anthropologie, an institution which in the late nineteenth century had the greatest number of courses on evolution of any institution in the world.[80] This group also helped to establish the first chair of evolutionary biology at the Sorbonne. Altogether, they so freely mixed science, left-wing politics, and anti-clericalism that their linear model came to be inextricably identified with a specific social scientific context.

Boule not only opposed the linear model of this cluster, but he also believed that it was time to end the linkage of paleontological theory to specific social commitments. He attacked Mortillet for his continued use of political and religious criteria in assessing contributions to the study of prehistory.[81] He felt that the political and anti-religious combativeness of Mortillet's circle could only hinder the growth of the community,[82] a cause dear to Boule's heart. In particular, Boule thought it was possible to transcend the barriers which orthodox clerics had established against evolution. He realized that many clerics 'considered the doctrine of evolution as coming straight from Hell and its supporters as henchmen of Satan',[83] but he also felt that other 'enlightened spirits were not lacking in

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the clergy',[84] men who would not avoid studying these new fields of science. In fact, many of Boule's associates in the struggle against the Mortilletian tradition, such as the Abbé Henri Breuil, were clerics; and, appropriately, it was three other clerical prehistorians who discovered the La Chapelle-aux-Saints skeleton and sent it to Boule.

Boule's laboratory sheltered both political radicals and conservatives as long as their work reached his high methodological standards.[85] Furthermore, his strict silence on causal controversies helped to defuse the embittered French traditions of the Mortilletians and Cuvierians. As his student Teilhard de Chardin correctly noted, Boule's works were written in 'a great spirit of conciliation'.[86]

It is important to note that Mortillet's mixture of science and politics should not be taken simply as an example of research distortion due to 'extra-scientific' factors. Many paleontologists have returned today to a model very much like that of Mortillet, who recognized the Neanderthals and *Homo erectus* as two stages in human evolution.[87] Furthermore, as Eugene Frankel has shown in his study of French optical physics, in the face of a centralized and institutionally embedded group defending what was perceived as scientific orthodoxy, an innovative scientist must make a decision about where to promote his own research.[88] Mortillet correctly perceived that linear and materialist evolutionary theory had no chance in the Museum and the Academy in late nineteenth-century France, and he set out to establish a scientific network outside this tradition, marshalling all possible social and scientific resources in his struggle to promote his vision of human prehistory. However, this decision also left Mortillet institutionally vulnerable, since he was unable to tap the enormous resources of the Academy and the Museum. When he died, only the École d'Anthropologie defended his tradition, and those ideas were already under severe attack from Boule in the Museum. In contrast, at a time when evolution was more accepted in the highest French scientific circles, Boule chose to remain within the Museum tradition, while advocating his own reconstruction of human evolution.

In regard to La Chapelle-aux-Saints, all these differences between Mortillet and Boule may have increased Boule's attraction to the branching alternative to Mortillet's linear solution for the Neanderthal problem. After all, Boule's selective perceptions and research decisions did finally result in the displacement of the last

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remaining serial ladder in the Mortilletian tradition, and set the stage for the emergence of a new research programme with contrasting ideas on causality, evolutionary models, and sociopolitical commitments.

Fortuitous Fraudulence

The definitiveness of Boule's conclusions on the Neanderthals suffered from the fact that a great gap remained in the paleontological record. At the end of the first decade of this century, there existed no clear evidence for a pre-Neanderthal population with morphological specializations significantly different in their pattern of development than those of the Neanderthals, and which therefore could be taken as an indication of a more sapiens-like line of evolutionary change. Obviously, if the Neanderthals were not ancestral to man, there must have existed other populations undergoing other evolutionary developments. If no such populations were discovered, there was every likelihood that Boule's general conclusions, as well as his La Chapelle-aux-Saints reconstruction, would be re-examined in the hope of clearing up this dilemma.

This did not occur for decades, in part because Boule's earlier good fortune in receiving the La Chapelle-aux-Saints skeleton continued when the Piltdown Man quickly appeared to confirm his theory of Neanderthal extinction. In December 1912, just as Boule was completing his majestic Neanderthal publications in the *Annales de Paléontologie*, the English paleontological community received its first public presentation of this remarkable fossil, which displayed exactly the requisite features should the Neanderthals not be ancestral to man. With its noble skull lacking the prominent Neanderthal brow ridges and the retreating forehead, and with its simian jaw, the Piltdown Man pointed to other populations in European prehistory which were morphologically very different from the Neanderthals. Also, since the Piltdown remains were given a pre-Neanderthal dating in the early Pleistocene, the forgery apparently provided real evidence for the branching evolution envisaged by Boule. I have dealt elsewhere with the crucial role of Boule's Neanderthal expulsion in preparing the international community for the appearance of a non-Neanderthal fossil such as Piltdown Man;[89] but, in addition, this relationship meant that support for Piltdown Man also meant support for the idea of Neander-

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thal extinction without posterity. For instance, Arthur Smith Woodward, the first paleontologist to reconstruct Piltdown, concluded that the fossil confirmed the theory that the Neanderthals were a 'degenerate offshoot' in human evolution.[90]

Even if the Piltdown association of modern brain case and simian jaw was accidental, as Boule believed,[91] and even if the Piltdown Man was not directly ancestral to man, as he also believed,[92] there could be, according to Boule, no doubt now about the great variety of populations in the family of man throughout prehistory.[93] This proven variety also meant that any scientist who thought that Boule had exaggerated one or another minor aspect of Neanderthal morphology, such as the foot,[94] could scarcely doubt that Boule's multilinear vision of prehistory was essentially correct.

In addition, Boule's branching model fitted nicely with the pre-Piltdown theoretical speculations of English paleontologists such as Arthur Keith on the high antiquity of modern man, William Sollas on morphological irregularity in evolution, and Grafton Elliot Smith on the leading role of the brain in human evolution.[95] These theories, too, needed the purging of the Neanderthals from human ancestry.[96] For instance, since the Neanderthal lower face seemed to be more modern in morphology than the skull, indicating that the modernization of the rest of the body might have preceded the modernization of the brain, Elliot Smith's theory on the precocious role of the brain would be most difficult to defend if the Neanderthals were in fact ancestral to man. Naturally, Elliot Smith was a keen supporter of Boule's Neanderthal research, referring to it as a 'masterly account' of this 'uncouth and repellent' population.[97] As for the Piltdown Man, 'the apparent paradox of the association of a simian jaw with a human brain' was according to him actually a 'tangible confirmation' of his idea that 'in the evolution of man the brain led the way'.[98]

Boule's postulation of Neanderthal extinction had the unintended consequence of paving the way in England for this infamous forgery, whose genius was not in its methodological sophistication, but rather in its theoretical plausibility. For a knowledgeable amateur like Charles Dawson, the work of Boule and his English colleagues was an inspiration, a protective screen, and even an alibi. If these eminent scientists were correct, something like Piltdown Man almost certainly existed in prehistory, so that Dawson was only jumping the gun in claiming priority for what was an inevitable discovery in the near future. Even if exposed, Dawson

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could claim that he too was taken in by the plausibility of the forgery, and that he was only the victim of a hoax perpetrated by yet another person. Of course, Dawson never had to face this problem, for the forgery was well protected by the wave of theoretical speculation that had swept the community just before Piltdown's dramatic emergence.

Ironically, the Neanderthal expulsion also served as the example for handling the peculiar morphological specializations of this fossil. Piltdown Man was also given the Neanderthal treatment, and expelled to a collateral and dead-end branch of evolutionary development.[99] In turn, as a result of this forgery, there seemed to be no reason to challenge Boule's conclusions on the Neanderthals. Indeed, after the emergence of Piltdown Man, Boule's solution was thought to be so definitive that many Neanderthal skeletons discovered in Europe around that time were not fully reconstructed or reported upon in any detail.[100] Specifically, no one seemed to see any necessity in restudying La Chapelle-aux-Saints, as Piltdown Man made a replication study appear fruitless. Instead, paleontologists turned their attention from such distant cousins of man to search prehistory for his true ancestry, temporarily lost in the shadows of the distant past.

International Rivalries

Although the emergence of the Piltdown Man meant that the English community was unlikely to challenge Boule's ideas on Neanderthal extinction, there still remained the strong German community, whose leaders (such as Gustav Schwalbe) had often advocated ancestral status for the Neanderthals.[101] However, once again, circumstances were to intervene as personal antagonisms, theoretical changes, and international war separated the French and German communities and decreased the likelihood of a successful German challenge to Boule's research.

Boule took only five weeks to prepare and present his first data and most important conclusions to the Academy of Sciences. This speed was due in part to a priority concern related to the activities of the German-Swiss prehistorian, Otto Hauser, and his friend, Hermann Klaatsch, professor of comparative anatomy at the University of Breslau in Germany. In April 1908, Hauser had uncovered a Neanderthal skeleton at Le Moustier, and called in

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Klaatsch to help with the excavation and reconstruction. Hauser then sold the Le Moustier skeleton to a German museum for 125,000 marks, a princely sum indicative of the interest in the Neanderthal question in 1908. Such a desecration of French soil infuriated Boule, who had long sought to have strict licensing of all excavation in France and control of the export of prehistoric discoveries.[102] The fact that Le Moustier had been found by Hauser, who had referred to French prehistorians as 'dilettanti, sensation-mongers, and picnickers',[103] only made things worse. Boule therefore wasted no time whatsoever in making his findings public, and later making sure that the Germans did not steal scientific glory as, in his opinion, they stole scientific data.[104]

Boule was perfectly right in his concern. Based upon the Le Moustier Neanderthal and the Combe Capelle *Homo sapiens*, which had been discovered by Hauser in 1909 and dated, like Grimaldi Man, as almost contemporary with the Neanderthals, Klaatsch also reached the conclusion that the Neanderthals were not ancestral to man. However, Klaatsch had a different theoretical interpretation of this finding, for he was primarily concerned with proving that various species of existent apes were the degenerate forms of early man — believing, for example, the gorilla to be related to the Neanderthals. In all this, Boule criticized Klaatsch's Le Moustier reconstruction, ridiculed his theoretical extrapolations, and carefully defended his priority.[105]

Relations between the French and German communities were also deteriorating in the face of rising international political tensions. With the outbreak of World War I, the Neanderthal issues were quickly submerged in a sea of vitriolic French-German scientific polemics. Boule filled his journal, *L'Anthropologie*, with story after story about the nefarious escapades of Hauser and his henchman, Klaatsch.[106] Called upon to write an article in defence of French science from a paleontological perspective, Boule not only exalted the glories of his nation's science, but also labelled the Germans 'a monstrous anachronism in the evolution of humanity' and compared their science to the grotesque and over-specialized reptilian dinosaurs doomed to extinction.[107] The significance of all this in regard to La Chapelle-aux-Saints was that any concern with the differing Neanderthal reconstructions and evolutionary models in the two communities virtually disappeared as both sides turned to defending their national honour.

British-German ties were also strained as Britain joined France in

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the war against Germany, just as symbolically the French Neanderthal expulsion and the British Piltdown Man were allies for the new branching vision of human evolution. During the war years, there was a radical decline in the amount of paleontological research done throughout Europe, and the war created many barriers to traditional paths of scientific discourse and communication. After the war, German paleontology never fully recovered, as the death of Klaatsch, and of other eminent scientists such as Gustav Schwalbe, left the community leaderless. Social and political problems in post-World War I Germany overwhelmed small scientific disciplines such as paleontology, and the likelihood of a German re-examination or criticism of Boule's research declined even further. Thus, united in their advocacy of Neanderthal extinction, it was the French and British communities that came to dominate international paleontology after the Great War.

New Institutionalization and Improved Strategic Position

Boule's Neanderthal research not only played a key role in the Piltdown episode, but also resulted in a new institutional base for his emerging research programme. Albert I, Prince of Monaco, had long been interested in the origin of life and had financed many deep sea research projects devoted to this problem. He was also deeply interested in the origins of man and funded such work as the Grimaldi research of Boule and Cartailhac. When Albert I saw Boule's public exhibition on the tragic fate of the Neanderthals at the Museum of Natural History, he was so moved by the implications of that research that he decided to found the first institute in the world exclusively devoted to studying problems of human evolution, such as those raised by the removal of the Neanderthals from human ancestry.[108] This institute was to be free from the constraints that a state supported institution ultimately accountable to the Ministry of Public Instruction might feel when studying such a socially sensitive area as human evolution.[109]

Naturally, Boule was the scientist most fit to head the Institut de Paléontologie Humaine (IPH), and Boule's first appointments were two old friends and evolutionary clerics, Hugo Obermaier and Henri Breuil. Boule described the IPH as the 'finest instrument for research till now available for prehistorians',[110] and his position at

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its head made him even more powerful in the community. With his control over the extensive research and publishing funds of the IPH, in addition to the facilities he already controlled at the Museum, Boule was in an excellent position to promote successfully his vision of prehistory through the 1920s and 1930s.

From this lofty position, Boule resolved the problem of the *Homo erectus* discoveries from Java and China, as well as Dart's Australopithecine discovery, by giving them the 'doubly fossil' Neanderthal treatment and assigning them to extinct branches in the family of man.[111] Indeed, Boule's rejection of ancestral status for these many fossil populations was a key part in the emergence of a rather anomalous situation for human paleontology. Modern man was recognized as having many cousins and uncles, but no lineal forefathers. He was, in the words of one observer, 'ancestorless man'.[112] Thus, almost two-thirds of a century after Darwin, the descent of man was still a mystery, and young paleontologists such as Louis Leakey searched the remote corners of the earth for that elusive population that had bypassed the Australopithecines, *Homo erectus*, and the Neanderthals in the evolution of man.[113]

Boule's Neanderthal conclusions did not go totally unchallenged in these years. For instance, Réné Verneau in France and Ales Hrdlicka in America ignored the Piltdown question and advanced theories which returned the Neanderthals to a stage in human evolution.[114] Boule greeted these with a magisterial silence, and let colleagues such as Grafton Elliot Smith defend Neanderthal extinction.[115] He also ignored works by Hans Weinert and Franz Weidenreich, who both accepted multilinear evolution but still found an ancestral niche for the Neanderthals.[116] When the other leaders of the international community either ignored or dismissed these challenges, the Neanderthals remained excluded from human ancestry. Such a silence reflected well the scientific politics of Boule, who tried to avoid unnecessary controversies about issues which in his mind had already been decided, such as the fate of the Neanderthals.

Boule never wavered in his commitment to his original Neanderthal conclusions. Even the discovery of the seemingly more sapiens-like Palestinian Neanderthals in the early 1930s, which started several paleontologists re-thinking the Neanderthal question, left Boule unaffected. Thus, Boule shared with Cuvier and Mortillet a passionate and uncompromising dedication to his scientific vision, and

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especially to the branching metaphor, which became a virtual object of devotion in his career. As Ian Mitroff has noted,[117] such an attitude is by no means rare among scientists and may in fact be a regular part of a successful scientific career. Moreover, this dogged determination seemed perfectly compatible with an almost rhapsodic view of the nature of science. As noted earlier, Boule was a scientific idealist who willingly submerged himself in the trials and glories of the search for 'Truth'.[118] In his devotion to this quest, 'one of the principal sources of happiness', Boule assigned a minor role to scientific honours,[119] and he even refused to seek a seat in the Academy of Sciences because he felt that the protocol visits and other administrative chores were too time consuming for a still productive scientist.[120] Instead, he could take pride in the knowledge that his model of irregular evolutionary change as a 'succession of broken lines' was being shown useful in a number of related problem areas,[121] and that his students, such as Teilhard de Chardin, Jean Piveteau, Camille Arambourg and Henri Vallois, were becoming world renowned scientists.

Conclusion

While his beloved France was occupied by his traditional enemies, the Germans, Boule died in 1942, ending one of the most distinguished careers in twentieth-century paleontology. He had helped to create a theory rich in the promise of glory for the scientist who could unearth mankind's true ancestor which somehow had prospered while so many other populations became evolutionary dead ends. However, despite the early heroic efforts of scientists such as Louis Leakey, Boule never lived to see that promise fulfilled. Indeed, after World War II, more and more paleontologists began to re-analyze the Neanderthal problem, and Boule's work itself came under heavy attack. Although some scientists, especially in the French and British traditions, continued to defend the Neanderthal expulsion by using new fossil discoveries, many paleontologists, especially in America, came to readmit the Neanderthals to human ancestry. Just as Boule's Neanderthal research is inseparable from the social fabric in which it was woven, so too is the Neanderthal revival rooted in a complex mixture of elements spanning not two but three national traditions. However, describing this continuation of the Neanderthal saga goes beyond

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the boundaries of this paper.

In the case of Boule and the Neanderthals, I have argued that certain social and theoretical commitments tied to his location in the Museum of Natural History and the French paleontological community were absolutely crucial in shaping the emergence of Boule's Neanderthal caricature, and in giving so much plausibility to the slouching posture and tragic Neanderthal fate. I have also presented some of the factors that gave Boule's research its monumental status in the eyes of his contemporaries, such that his work was not re-examined in detail during his lifetime. The different aspects analyzed here in linking scientific research and social context are by no means meant to be an exhaustive catalogue of such ties, but hopefully they might serve some comparative value for studies which seek to reconstruct science as it is embedded in specific contexts. When Boule's work is cast in such terms, we can better understand the vision of the Neanderthals as lamentable cave brutes emerging from the shadows of distant prehistory and shuffling towards evolutionary extinction.

● NOTES

1. W.L. Straus and A.J.E. Cave, 'Pathology and the Posture of Neanderthal Man', *Quarterly Review of Biology*, Vol. 32 (1957), 348-61.

2. Camille Arambourg, 'Sur l'Attitude, en Station Verticale, des Néanderthaliens', *Comptes rendus de l'Académie des Sciences de Paris*, Vol. 240 (1955), 804-06; Émile Patte, *Les Néanderthaliens: Anatomie, Physiologie, Comparaisons* (Paris: Masson, 1955).

3. Such as, for instance, the wedging of the last lumbar vertebral body, the ellipsoid shape of the femoral condyles, and the presence (at least on La Ferrassie I and II) of first-to-second metatarsal articular facets.

4. Arambour, op. cit. note 2.

5. For a summary of this position, see Barry Barnes and Steven Shapin, 'Introduction', in Barnes and Shapin (eds), *Natural Order: Historical Studies of Scientific Culture* (London and Beverly Hills, Calif.: Sage Publications, 1979), 9-13.

6. See Barry Barnes, *Interests and the Growth of Knowledge* (London: Routledge and Kegan Paul, 1977), 1-2; and Barnes and Shapin, op. cit. note 5, 187-88.

7. Marcellin Boule, *Fossil Men* (Edinburgh: Oliver and Boyd, 1923), 178-94. For a different view of the same history, as well as a discussion of later developments, see C. Loring Brace, 'A Consideration of Hominid Catastrophism', *Current Anthropology*, Vol. 5 (1964), 3-43.

8. Arthur Keith, *Ancient Types of Man* (London: Harper, 1911), 26.

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9. Gabriel de Mortillet, *Le Préhistorique, origine et antiquité de l'homme* (Paris: Reinwald, 1900), 122-27, 290-302.

10. Marcellin Boule, 'L'Homme Fossile de la Chapelle-aux-Saints', *Annales de Paléontologie*, Vol. 7 (1912), 213-14.

11. Ibid., 214.

12. For instance, he never published a separate monograph on these two skeletons, nor did they play as important a role as La Chapelle-aux-Saints in Boule's classic textbook, *Les Hommes fossiles*, op. cit. note 7.

13. Boule, op. cit. note 10, 149-50.

14. Marcellin Boule and Raoul Anthony, 'L'Encéphale de l'Homme Fossile de la Chapelle-aux-Saints', *L'Anthropologie*, Vol. 22 (1911), 129-96.

15. See for instance, Marcellin Boule, 'L'Homme Fossile de la Chapelle-aux-Saints', *L'Anthropologie*, Vol. 19 (1908), 519; and 'L'Homme Fossile de la Chapelle-aux-Saints', ibid., Vol. 20 (1909), 260, 264.

16. These are summarized in Boule, op. cit. note 15 (1908), 519-25; and (1909), 257-71.

17. Boule and Anthony, op. cit. note 14.

18. Marcellin Boule, 'L'Homme Fossile de la Chapelle-aux-Saints', *Annales de Paléontologie*, Vol. 6 (1911), 1-64; Vol. 7 (1912), 65-208; Vol. 8 (1913), 209-79.

19. Boule, op. cit. note 18 (1913), 246.

20. Straus and Cave, op. cit. note 1, 221. Boule originally reported only 18 vertebrae, but apparently two additional lumbar vertebrae were found at a later date.

21. Ibid., 228

22. Boule, op. cit. note 15 (1908), 521; and op. cit. note 18 (1912), 97, 107, 145.

23. Norwood R. Hanson, *Patterns of Discovery* (Cambridge: Cambridge University Press, 1958), 4-30; and *Perception and Discovery* (San Francisco, Calif.: Freeman, Cooper, and Company, 1969), 111-28.

24. Straus and Cave, op. cit. note 1, 222.

25. Thus, Boule could set aside the work of A.-F. Le Double, *Traité des variations de la colonne vertébrale de l'Homme et de leur signification au point du vue de l'anthropologie zoologique* (Paris: Vigot Frères, 1912), which showed that bifidity or non-bifidity does not in itself indicate an imperfectly erect posture.

26. Thus, as in note 25, Boule could bypass the work of scientists such as L. Manouvrier, R.H. Charles and A. Thomson, who had shown that such characteristics, once thought to be in themselves indicative of a stooping carriage, were not sufficient to point definitively to a less than fully erect posture.

27. Boule, op. cit. note 18 (1912), 183.

28. Ibid., 183-84.

29. Marcellin Boule, 'Réponse pour le Jubilé de M. Marcellin Boule', *L'Anthropologie*, Vol. 47 (1937), 611.

30. See for instance, Boule, op. cit. note 18 (1913), 269; and op. cit. note 7, xiii-xiv.

31. Boule, op. cit. note 29, 609.

32. Boule, op. cit. note 18 (1913), 269; and Camille Arambourg, *Paléontologie générale et paléontologie humaine; l'oeuvre de M. Marcellin Boule* (Paris: Doin, 1937), 6.

33. Henri Vallois, 'Marcellin Boule', *L'Anthropologie*, Vol. 50 (1941-46), 204.

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34. Marcellin Boule, 'La Paléontologie au Musée et l'Oeuvre de M. Albert Gaudry', *L'Anthropologie*, Vol. 15 (1904), 5.

35. Abbé Henri Breuil, 'Marcellin Boule', *Schweizerishen Gesellschaft für Urgeschichte*, Vol. 33 (1942), 155.

36. Michael Hammond, *The Rise of the Presapiens Theory of Human Evolution in French and British Paleontology: A Study in the Sociology of Scientific Ideas* (unpublished PhD dissertation, University of Toronto, 1977), Chapters 4 and 5.

37. For a general discussion of this resistance, see Yvette Conry, *L'Introduction du Darwinisme en France au XIX^e Siècle* (Paris: Vrin, 1974); and Robert Stebbins, *French Reactions to Darwin, 1859-1882* (Ann Arbor, Mich.: University Microfilms, 1965).

38. Arambourg, op. cit. note 32, 5, 8; and Boule, op. cit. note 34, 8, 10, 18, 28.

39. For instance, Albert Gaudry, 'Contribution à l'histoire des Hommes fossiles', *L'Anthropologie*, Vol. 14 (1903), 1; and 'Sur le berceau de l'Humanité', *Congrès international d'Anthropologie et d'Archéologie préhistorique. Compte rendu de la XIII^e session* (Monaco, 1907), 162.

40. Abbé Henri Breuil, 'Soixante Ans de Découvertes d'Hommes primitifs et leur Influence sur les Idées', in G.H.R. Von Koenigswald (ed.), *Hundert Jahre Neanderthaler* (Utrecht: Kemink En Zoon, 1958), 2.

41. See, for instance, David Bloor, *Knowledge and Social Imagery* (London: Routledge and Kegan Paul, 1976), 143.

42. Boule, op. cit. note 18 (1911), 4.

43. Marcellin Boule et P. Glangeaud, 'Le *Callibrachion Gaudryi*', *Bulletin de la Société d'Historie naturelle d'Autun*, Vol. 6 (1893), 1-8.

44. Marcellin Boule, 'Le *Canis megamastoides* du Pliocene moyen de Perrier', *Bulletin de la Société géologique de France*, Vol. 17 (1889), 321-31.

45. Marcellin Boule et Albert Gaudry, 'L'*Elasmotherium*', *Matériaux pour l'Histoire des Temps quaternaires*, Vol. 3 (1888), 1-22; Boule, 'Description de l'*Hyaena brevirostris* du Pliocène de Sainzelles, près Le Puy', *Annales des Sciences naturelles, Zoologie*, Vol. 15 (1893), 85-97; and 'Revision des Espèces européennes de Machairodus', *Bulletin de la Société géologique de France*, Vol. 4 (1901), 551-73.

46. Marcellin Boule, 'Essai de Paléontologie stratigraphique', *Revue d'Anthropologie*, Vol. 3 (1888), 272-97, 385-411, 647-80.

47. Marcellin Boule, *Les Grottes de Grimaldi: Résumés et Conclusions des Études Géologiques* (Monaco, 1906), 265.

48. Boule, op. cit. note 15 (1908), 525; and op. cit. note 18 (1913), 270.

49. Brace, op. cit. note 7; and Stephen Holtzman, 'On Brace's Notion of Hominid Catastrophism', *Current Anthropology*, Vol. 14 (1973), 306-08.

50. Marcellin Boule, 'Albert Gaudry', *L'Anthropologie*, Vol. 19 (1908), 610.

51. Boule, op. cit. note 18 (1913), 238.

52. Ibid., 250.

53. Ibid., 249.

54. Boule, op. cit. note 29, 608.

55. Boule, op. cit. note 7, 444, 468.

56. Ibid., 107-08; 'Le Sinanthrope', *L'Anthropologie*, Vol. 47 (1937), 1-32; and Marcellin Boule and Henri Vallois, *Fossil Men* (London: Thames and Hudson, 1957), 90-94.

57. Marcellin Boule, 'La Guerre et la Paléontologie', in Gabriel Petit et Maurice Leudet (eds), *Les Allemands et la Science* (Paris, 1916), 39.

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58. Boule, op. cit. note 18 (1913), 270.

59. Gerald Holton, *The Scientific Imagination: Case Studies* (Cambridge: Cambridge University Press, 1978), 7-9.

60. For instance, see Jean Piveteau, 'Discours pour le Jubilé de M. Marcellin Boule', *L'Anthropologie*, Vol. 47 (1937), 589; and Arambourg, op. cit. note 32, 7.

61. Boule, op. cit. note 18 (1913), 247.

62. Albert Gaudry, *Mammifères tertiaires* (Paris: Masson, 1877), 257: and *Essai de Paléontologie philosophique* (Paris: Masson, 1896), 3, 5, 209.

63. J. Gruber, 'Marcellin Boule', *Dictionary of Scientific Biography*, Vol. 2 (1970), 347. Brace, op. cit. note 7, has tried to explain this silence in terms of Boule's supposed Cuvierianism, but this seems all the more unlikely in the face of Boule's happiness with his reduction of the 'zoological isolation' between man and other species.

64. Boule, op. cit. note 7, 444, 468.

65. Mortillet, op. cit. note 9, 290-302.

66. Of course, if Boule had chosen to stress such cultural features, his conclusions might have been quite different; but, once again, his selective focus resulted in the minimization of all cultural factors.

67. Boule, op. cit. note 18 (1913), 249.

68. Imre Lakatos, 'Falsification and the Methodology of Scientific Research Programmes', in Lakatos and Alan Musgrave (eds), *Criticism and the Growth of Knowledge* (Cambridge: Cambridge University Press, 1970), 132-34.

69. For a discussion of Mortillet's programme, see Michael Hammond, 'Anthropology as a Weapon of Social Combat in Late Nineteenth-Century France', *Journal of the History of the Behavioral Sciences*, Vol. 16 (1980), 118-32. For a discussion of the relationship of Mortillet's social location to his theoretical structure, and of the general relationship in late nineteenth-century France between the social distance of scientists from the Museum establishment and the theoretical distance of their ideas from the Museum orthodoxy, see Michael Hammond, 'The Emergence of Combat Anthropology: A Case Study in the Production and Utilization of Social Science Knowledge', in B. Holzner, K. Knorr and H. Strasser (eds), *The Political Realization of Social Science Knowledge and Research* (Wurzburg: Physica Verlag, Spring 1982).

70. Mortillet, op. cit. note 9, 122-27, 290-302.

71. Ibid., 21, 241, 368. Geologists today recognize a number of such periods.

72. Now generally labeled 'Mousterian'.

73. Boule, op. cit. note 46.

74. Marcellin Boule, 'Mortillet, (G. de), Évolution quaternaire de la Pierre', *L'Anthropologie*, Vol. 8 (1897), 344; and 'Gabriel et Adrien de Mortillet, "Le Préhistorique"', ibid., Vol. 12 (1901), 428.

75. Mortillet, op. cit. note 9, xi-xii; and Hammond, op. cit. note 69 (1980), 119-20, 127-29.

76. Gabriel de Mortillet, *Les Mystifiés de l'Académie des Sciences* (Paris: Marpon, 1865), 3.

77. Gabriel de Mortillet, 'La Foi et la Raison dans l'Étude des Sciences', *Revue Mensuelle de l'École d'Anthropologie de Paris*, Vol. 6 (1896), 4.

78. Gabriel de Mortillet, *Le Signe de la Croix avant le Christianisme* (Paris: Reinwald, 1866).

79. Hammond, op. cit. note 69 (1980), 126.

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80. Henri Thulié, *L'École d'Anthropologie de Paris* (Paris: Alcan, 1907), 2-4; and Hammond, op. cit. note 69 (1980), 127-29.

81. Boule, op. cit. note 74 (1901), 428, 430.

82. Marcellin Boule, 'Dr Paul Girod', *L'Anthropologie*, Vol. 22 (1911), 621.

83. Marcellin Boule, 'Guibert (J.), Les Origines', *L'Anthropologie*, Vol. 7 (1896), 331. In contrast to his Mortillet reviews, Boule bent over backwards to be gentle with clerical writings as long as they affirmed the basic fact that man had evolved. See, for instance, Marcellin Boule, 'Boulay (l'Abbé), L'Ancienneté de l'Homme d'après les Sciences Naturelles', *L'Anthropologie*, Vol. 6 (1895), 71-72; and 'Boulay (l'Abbé), Les Origines de l'Espèce humaine', ibid., Vol. 8 (1897), 460-62.

84. Boule, op. cit. note 83 (1896), 331.

85. Claude Cuénot, *Pierre Teilhard de Chardin* (Baltimore, Md.: Helicon, 1965), 18.

86. Quoted in Harry Paul, 'Religion and Darwinism: Varieties of Catholic Reaction', in Thomas Glick (ed.), *The Comparative Reception of Darwinism* (Austin, Texas: University of Texas Press, 1974), 434.

87. See, for instance, Brace, op. cit. note 7.

88. Eugene Frankel, 'Corpuscular Optics and the Wave Theory of Light: The Science and Politics of a Revolution in Physics', *Social Studies of Science*, Vol. 6 (1976), 144-84.

89. Michael Hammond, 'A Framework of Plausibility for an Anthropological Forgery: The Piltdown Case', *Anthropology*, Vol. 3 (1979), 47-58.

90. Arthur Smith Woodward, 'On the Discovery of a Paleolithic Human Skull and Mandible in a Flint-bearing Gravel Overlying the Wealden (Hastings Beds) at Piltdown, Fletching (Sussex)', *Quarterly Journal of the Geological Society of London,* Vol. 69 (1913), 139.

91. Boule, op. cit. note 7, 172-74.

92. Ibid.

93. Marcellin Boule, 'L'Homme fossile de Piltdown, Sussex (Angleterre)', *L'Anthropologie*, Vol. 23 (1912), 744; and 'La Paléontologie humaine en Angleterre', ibid., Vol. 26 (1915), 66.

94. See, for instance, D.J. Morton, 'Significant Characteristics of the Neanderthal Foot', *Natural History*, Vol. 26 (1926), 310-14.

95. Keith, op. cit. note 8; W. Sollas, 'The Anniversary Address of the President', *Quarterly Journal of the Geological Society of London*, Vol. 66 (1910), lxii-lxxxviii; and G.E. Smith, 'Some Problems Relating to the Evolution of the Brain', *Lancet*, New Series, Vol. 1 (1910) (1 January), 1-6; (15 January), 147-54; (22 January), 221-27.

96. Hammond, op. cit. note 89, 51-53.

97. Grafton Elliot Smith, *The Evolution of Man* (Oxford: Oxford University Press, 1924), 41, 69. See also 'Neanderthal Man *Not* Our Ancestor', *Scientific American*, Vol. 139 (August 1928), 112-15.

98. Grafton Elliot Smith, 'Appendix on Piltdown', *Quarterly Journal of the Geological Society of London*, Vol. 69 (1913), 147; and op. cit. note 97 (1924), 67-68. Similarly, William Sollas, another English paleontologist who warmly greeted the Piltdown Man, supported Boule's conclusions, described Boule's work as a 'masterpiece', and reproduced in his own classic textbook Boule's skeletal drawing of the slouching brute: see Sollas, *Ancient Hunters and Their Modern Represen-*

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tatives (New York: Macmillan, 1915), 198. The importance of Boule's work to the international community is also reflected in Sollas's earlier comment that 'the osteology of the Neanderthal race was known only in piecemeal until Professor Boule described the skeleton of La Chapelle' (op. cit. note 95, lxxxv).

99. See, for instance, Boule, op. cit. note 7, 174; Elliot Smith, op. cit. note 97 (1924), 2; and A. Keith, *The Antiquity of Man* (London: Williams and Norgate, 1915), 505, 509.

100. Brace, op. cit. note 7, 4.

101. Gustav Schwalbe, *Studien zur Vorgeschichte des Menschen* (Stuttgart: E. Scheizerbart, 1906).

102. See, for instance, Marcellin Boule, 'Discussion de la conservation des stations quaternaires', *L'Anthropologie*, Vol. 12 (1901), 340-41.

103. Quoted by Herbert Wendt, *In Search of Adam* (Boston, Mass.: Houghton Mifflin, 1956), 386.

104. Marcellin Boule, 'Découverte d'un Squelette du Type du Neanderthal sous l'Abri inférieur du Moustier', *L'Anthropologie*, Vol. 20 (1909), 220-21; and op. cit. note 57, 36.

105. Boule, op. cit. note 18 (1913), 215, 267. Boule published three weeks earlier than his opponents.

106. See, for instance, Marcellin Boule, 'La Guerre', *L'Anthropologie*, Vol. 25 (1914), 575-80; 'La Guerre et M. Hauser', ibid., Vol. 26 (1915), 169-82; 'La Psychologie des Allemands actuels', ibid., 295-98; and 'Encore le célèbre HAUSER', ibid., Vol. 28 (1917), 183-85.

107. Boule, op. cit. note 57, 37, 40, 42.

108. Marcellin Boule, 'L'Oeuvre anthropologique du Prince Albert I^{er} de Monaco', *L'Anthropologie*, Vol. 32 (1922), 12-13.

109. A. Lacroix, 'Discours pour le Jubilé de M. Marcellin Boule', *L'Anthropologie*, Vol. 47 (1937), 603.

110. Boule, op. cit. note 7, xv.

111. Boule, op. cit. note 56.

112. J.M. Gillette, 'Ancestorless Man: The Anthropological Dilemma', *Scientific Monthly*, Vol. 57 (1943), 533-45.

113. Of course, Leakey later claimed to have found just such a fossil with his discovery of *Homo habilis*.

114. Réné Verneau, 'La Race de Néanderthal et le Race de Grimaldi: Leur Rôle dans l'Humanité', *Journal of the Royal Anthropological Institute*, Vol. 54 (1924), 211-30; and Ales Hrdlicka, 'The Neanderthal Phase of Man', ibid., Vol. 67 (1927), 249-74.

115. Elliot Smith, op. cit. note 97 (1928).

116. Hans Weinert, *Der Schädel des eiszeitlichen Menschen von le Moustier in neuer Zussammensetzung* (Berlin: J. Springer, 1925); and Franz Weidenreich, 'Entwicklungs- und Wassentypen des *Homo primigenius*', *Natur und Volk*, Vol. 58 (1928), 1-13, 51-62. In both cases, the model was that of multiple parallel lines of evolutionary development in different parts of the world, with the Neanderthals tied to the evolution of man in Europe.

117. Ian Mitroff, 'Norms and Counter-Norms in a Select Group of the Apollo Moon Scientists: A Case Study of the Ambivalence of Scientists', *American Sociological Review*, Vol. 39 (1974), 579-95.

118. Boule, op. cit. note 29.

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119. Ibid., 611.
120. Vallois, op. cit. note 33, 209; and Arambourg, op. cit. note 32, 10.
121. Boule, op. cit. note 7, 466-67.

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